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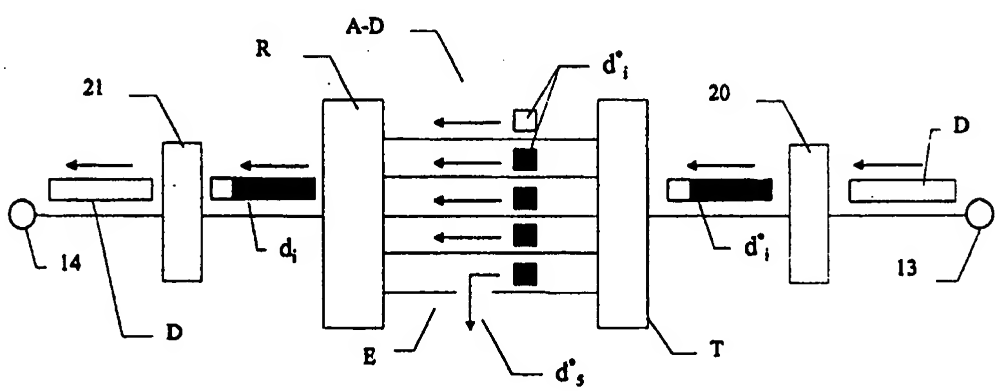

(57) Abstract

A method of and apparatus for transferring data between a source and a destination where there are plural communication paths between the source and the destination are provided. The data is divided into m discrete units each containing a portion of the data. The m discrete units are transformed into m+n transformed data units where n≥1. Each of said m+n transformed data units is transmitted from said source over the paths such that at least two paths are used for the transmission of the transformed data units from the source. The data is reconstructed from at least m transformed data units received at the destination.

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DATA TRANSFER METHOD AND APPARATUS

The present invention relates to a data transfer method and apparatus.

In our International patent application no. PCT/GB97/03472 and our British patent application no. 9726873.4, the entire disclosures of which are incorporated herein by reference, there is disclosed a communications apparatus comprising a mesh of interconnected nodes. Each node can communicate with plural other nodes via point-to-point radio links between nodes by means of substantially unidirectional radio transmissions along the links. In a typical example, each node has eight links providing a connection from each node to eight other nodes. Time division duplex (TDD) is used to alternate transmission and reception modes along a link. In a preferred embodiment, time division multiplexing (TDM) is used to control the timing of transmission and reception between the links. For example, a node is able to transmit along a first link in a first time slot of a transmission portion of a time frame, along a second link during the second time slot of the transmission portion of the time frame, etc., for eight transmission time slots for the eight links. The node then is able to receive along the first link during a first time slot of the reception portion of the time frame, along the second link during the second time slot of the reception portion of the time frame, etc., for eight reception time slots for the eight links. As an alternative to TDM, frequency division multiplexing (FDM) or other techniques such as code division multiple access (CDMA) may be used.

In our PCT/GB97/03472 and our British patent application no. 9726873.4, it was broadly described how a benefit of the communications apparatus is that there are normally plural choices of path for communicating between any particular pair of nodes. The present invention

relates to a method and apparatus for exploiting this feature in order to provide highly reliable communication between nodes.

According to a first aspect of the present invention, there is provided a method of transferring data between a source and a destination where there are plural communication paths between the source and the destination, the method comprising the steps of: dividing the data into m discrete units each containing a portion of the data; transforming said m discrete units into m+n transformed data units where n≥1; transmitting each of said m+n transformed data units from said source over the paths such that at least two paths are used for the transmission of the transformed data units from the source; receiving at least some of the transformed data units at the destination; and, if at least m transformed data units are received at the destination, reconstructing at the destination the data from at least m transformed data units received at the destination.

The present invention provides for highly reliable transmission of data between a source and a destination by taking advantage of the possibility of using multiple paths for the circuit set up between the source and the destination. This is achieved without requiring unrealistic levels of reliability of the individual paths themselves. This is particularly advantageous in a wireless transmission system.

There are preferably at least m+n transmission paths between the source and the destination and the transmitting step preferably comprises transmitting each of said m+n transformed data units from said source over a different one of the paths.

The m discrete data units preferably each contain a different portion of the data. This leads to increased efficiency of data transfer because the minimum amount of bandwidth is used as there is no repetition of data across the discrete data units.

The method may comprise the step of sending an error signal to the source to indicate transmission failure if less than m transformed data units are received at the destination after a predetermined time has elapsed after said transmitting step.

The transmission may be a wireless transmission.

In a preferred embodiment, each of the paths is formed from at least one point-to-point wireless transmission link between the source and the destination.

According to a second aspect of the present invention, there is provided apparatus for transferring data between a source and a destination where there are plural communication paths between the source and the destination, the apparatus comprising: a divider for dividing the data into m discrete units each containing a portion of the data; means for transforming said m discrete units into m+n transformed data units where $n \geq 1$; a transmitter for transmitting each of said m+n transformed data units from said source over the paths such that at least two paths are used for the transmission of the transformed data units from the source; a receiver for receiving at least some of the transformed data units at the destination; and, means for reconstructing at the destination the data from at least m transformed data units received at the destination if at least m transformed data units are received at the destination.

The transmitter is preferably arranged to transmit each of said m+n transformed data units from said source over a different one of the paths.

The divider is preferably arranged to divide the data such that each of the m discrete data units contains a different portion of the data.

Means may be provided for sending an error signal to the source to indicate transmission failure if less than m transformed data units are received at the destination after a predetermined time has elapsed after said transmitting step.

The transmitter may be arranged to transmit wireless transmissions.

In a preferred embodiment, each of the paths is formed from at least one point-to-point wireless transmission link between the source and the destination.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 shows schematically a conventional transmission circuit from one node to another according to the prior art;

Fig. 2 shows schematically a transmission circuit in accordance with an example of the present invention; and,

Fig. 3 is a schematic representation of the division, transformation, transmission, reception and reconstruction of a piece of user data in accordance with the present invention.

Referring to Figure 1, there is shown a first subscriber at a first node 1 who wishes to transfer data to a second subscriber at a second node 2. To achieve this, a virtual or logical circuit 3 is set up between the two nodes 1,2. (It will be appreciated by those skilled in the art that the following description and the present invention can easily be applied to "connectionless" data traffic also.) The virtual circuit 3 is constructed from several links 4, in general K links 4, via intermediate nodes 5 between the nodes 1,2 between which data is to be transmitted. The links 4 between the nodes 1,2 between which data is to be transmitted are connected in series. Thus, if the probability that a particular link 4 is available for transmission is P_{avail}, then the probability of the circuit 3 being available is $1-K(1-P_{avail})$ as only one link 4 needs to fail for the circuit 3 to be lost completely, assuming any link failures are uncorrelated. This is true whether the links 4 are wired or wireless or a mixture of wired and wireless.

Referring to Figure 2, there is shown a portion of a communications network 10 in accordance with the communication apparatus disclosed in our PCT/GB97/03472 and our British patent application no. 9726873.4. There are many nodes 11 which are each logically connected to other nodes 11 by point-to-point wireless transmission links 12 using substantially unidirectional wireless transmissions, i.e. signals are not broadcast but are instead directed to a particular node with signals being capable of being passed in both directions along the link 12. In the example shown in Figure 2, it is assumed that one of the nodes 13 wishes to transmit data to another node 14. This may be achieved by constructing a logical or virtual circuit 15 between the two nodes 13,14 between which data is to be transferred. The circuit 15 in the specific example shown in Figure 2 is constructed from four different paths A, B, C, D. Each of the transmission paths

A-D follows a different route via different nodes 11. As will be discussed further below, the actual number of paths chosen to form the circuit 15 can vary enormously depending on the data to be transferred, the reliability of service required, and the data traffic loading of the network 10 as a whole. Only the links 12 between nodes 11 actually being used for carrying traffic between the nodes 13,14 are shown in Figure 2.

As with the prior art example shown in Figure 1, the probability that a particular path A-D is available for transmission is the probability that a particular link 12 is available, i.e. $P_{avail}(\text{path}) = 1\text{-}K(1\text{-}P_{avail}(\text{link on path}))$.

A piece of data D which is intended for transmission from one node 13 to another node 14 across the network 10 can be split into m separate fragments or units $\{d_i, i=1 \text{ to } m\}$. In accordance with the present invention, the m discrete data units d_i are transformed by an appropriate algorithm into m+1 transformed data units $\{d^*_i, i=1 \text{ to } m+1\}$. The transformation from the original data units d_i to the transformed data units d^*_i is such that the m original data units d_i can be reconstructed from any m of the transformed data units d^*_i.

As a simple example, the transformation from the discrete data units d_i into the transformed data units d^*_i can be by means of an appropriate arbitrary matrix C which, in this example, is a m x m+1 matrix. Thus, $d^*_i = C_{ij}.d_j$. In this example, all of the m original data units d_i can be computed exactly from any m of the transformed data units d^*_j by making the square m x m matrix C'_{ij} from the columns of the transformation matrix C_{ij} which correspond to the particular m transformed data units d^*_i and using its inverse C'^{-1}.

For example, if m = 4, then $C = \{c_1\ c_2\ c_3\ c_4\ c_5\}$, where the c_i are each four-element column vectors. The original piece of data D can be reconstructed from for example the received fragments $\{d^*_1\ d^*_2\ d^*_3\ d^*_5\}$, that is using all transformed data units d^*_i except for d^*_4, by the reconstruction $d = C'^{-1}.d^*$ where the reconstruction matrix C' is formed from the column vectors of the transformation matrix C except for the column vector corresponding to the absent transformed data unit d^*_i, i.e. here $C' = \{c_1\ c_2\ c_3\ c_5\}$, and C'^{-1} is the inverse matrix of C'.

Now, suppose that for every piece of user data $D = \{d_i,\ i=1 \text{ to } m\}$ to be transmitted between a pair of nodes 13,14 there is formed a transformed version of the data $D^* = \{d^*_i,\ i=1 \text{ to } m+1\}$ and that each transformed data unit d^*_i is sent over a different one of m+1 paths A-D constituting a circuit 15 as indicated by way of example in Figure 2. If a particular link 12 of a path j is unavailable thereby resulting in the loss of the transformed data unit d^*_j transmitted on that path j, the original piece of user data D can still be reconstructed at the receiving node 14 assuming that the transformation matrix C is known to the destination node 14 as well as to the source node 13.

This is indicated schematically in Figure 3. The source node 13 produces a piece of user data D, which may be for example a data packet. The user data D is divided at 20 by appropriate means, such as for example a computer running appropriate software, into m discrete data units $\{d_i,\ i=1 \text{ to } m\}$. In this example, m = 4. The m discrete data units $\{d_i,\ i=1 \text{ to } m\}$ are then transformed at 20, by for example a computer running appropriate software, into m+1 (here 5) transformed data units $\{d^*_i,\ i=1 \text{ to } m+1\}$. By way of example, the transformation may be carried out using a transformation matrix C as discussed above. The m+1 transformed data units d^*_i are transmitted at T by the node 13 over the circuit 15 with each of the individual

transformed data units d^*_i being transmitted over a different one of the m+1 paths A-E. As can be seen, the transformed data unit d^*_5 transmitted on path E is lost during transmission because, for example, one of the links 12 on path E has failed. Thus, in the example shown in Figure 3, only the first four transformed data units d^*_1, d^*_2, d^*_3, and d^*_4 are received at R by the destination node 14. At R, the four received transformed data units d^*_1, d^*_2, d^*_3, and d^*_4 can be acted upon, by for example a computer running appropriate software with an appropriate algorithm, to regenerate all of the m original data units $\{d_i, i=1 \text{ to } m\}$ even though the transformed data unit d^*_5 transmitted on path E was lost and only m transformed data units d^*_i were received. In the specific example described, the reconstruction of the original discrete data units d_i from the subset of transformed data units d^*_i actually received is made using the inverse matrix C'^{-1} where the reconstruction matrix C′ is formed from the transformation matrix C used at 20 but without the column (here the fifth column) which relates to the transformed data unit which has been lost (here the fifth transformed data unit d^*_5). The complete set of reconstructed data units d_i are passed to a buffer 21 associated with the destination node 14. The buffer 21 stores and reassembles the discrete data units d_i, taking into account the fact that different transformed data units d^*_i will have been received at different times according to the length of the particular transmission path A-D traversed by that transformed data unit d^*_i such that transformed data units d^*_i can be received out of sequence, thereby to reconstruct the original data D for the destination node 14.

In this method, where the m original data units d_i are transformed into m+1 transformed data units for transmission, a circuit 15 will only be lost (i.e. the original piece of user data D is not effectively received)

if at least two separate paths A-E have an unavailable link 12.

In general, a piece of user data D can be split into m discrete data units $\{d_i, i=1 \text{ to } m\}$. The m discrete data units $\{d_i, i=1 \text{ to } m\}$ can be transformed into m+n transformed data units $\{d^*_i, i=1 \text{ to } m+n\}$ where $n \geq 1$.

In general, the availability of a link $P_{avail}(\text{link})$ in this scheme can be related to the required circuit availability P_{avail} by:

$$P_{avail}(\text{link}) := 1 - \frac{\left(\frac{1 - P_{avail}}{W(m,n)}\right)^{\frac{1}{(n+1)}}}{K}$$

where:

$$W(m,n) := \frac{(m+n)!}{(m-1)! \cdot (n+1)!}$$

and K is the mean number of links per path.

To put this into context, if the required circuit availability is 99.997%, i.e. a circuit is unavailable for only 15.8 minutes per year, then with conventional transmission networks as shown in Figure 1, the availability of each link must be 99.99925% where K=4, i.e. there are four links, which is equivalent to a link unavailability of only about 4 minutes per year, meaning that the link availability must be much greater than the overall required circuit availability.

In the specific example of the present invention discussed above, where n=1, the probability of losing a link on an individual path A-D need only be 99.9965% (from the above expression with m=4, n=1, K=5) to achieve the same circuit reliability of 99.997%. This is equivalent to a link unavailability of over 3 hours per year. This means

that, in the simple example shown above where the m discrete data units d_i into which the original piece of user data D is initially fragmented are transformed into m+1 transformed data units d^*_i, the transmission circuits 15 which can be set up in accordance with the present invention have an availability (which is equivalent to reliability) which is approximately 11.6 times better than the availability of an individual link 12. This means that a wireless transmission network using the present invention can have a reliability and availability which is practically the same as available with conventional wired-networks and which far exceeds that available with conventional wireless networks assuming that the mean number of links per path does not become excessive.

If for example n=2 so that up to two paths of a circuit can be lost without there being a complete loss of data, then 99.997% circuit availability can be achieved with individual link availabilities of 99.771%, which is equivalent to an unavailability of 20 hours per year. This is equivalent to a decrease in the reliability of a link of a factor of nearly eighty compared to the overall reliability and availability of the circuit 15. In other words, the reliability required of any one transmission link is in principle very much less stringent when the present invention is implemented to transmit data.

It will be appreciated that this improved resilience requires that more data in total is always sent over the network 10 than is actually present in the original data D. For example, in the example described above, if the original piece of user data D is L bytes long, each original data unit d_i is L/m bytes, and each transformed data unit d^*_i is also L/m bytes long. Hence, if the m+n transformed units d^*_i are sent over m+n different paths, a total of L(m+n)/m bytes are sent. Thus, n-fold resilience requires (m+n)/m times the bandwidth of a circuit

constructed from a single path. Clearly, to reduce this bandwidth overhead it is desirable to make m as large as possible compared to n so that the bandwidth overhead factor tends to 1. However, in a multi-user network, allocating independent paths to a single circuit becomes more difficult and resource intensive as the number of paths per circuit increases. A compromise between minimising the number of paths per circuit and maximising the fragmentation of the message should normally be reached. This compromise will mainly depend on the degree of resilience required of a particular circuit given the availability of the individual radio transmission links in the system and the instantaneous traffic load in the system. For example, in a lightly loaded system, it will normally be more straightforward to allocate a large number of paths to a circuit than in a heavily loaded system.

As an example, if data D were split into four fragments, from which five transformed fragments were sent over five different paths on one circuit, this circuit would be 11.6 times more reliable than the individual links and would use 25% more bandwidth than a single path circuit. Transforming the data D into six fragments would provide over 77 times the individual link reliability, for 50% more bandwidth. Thus, this multipath-per-circuit feature allows the network operator to provide very high-reliability circuits on demand for modest bandwidth overheads as the reliability increases very much more rapidly than the bandwidth overhead.

This technique is well-suited to radio systems where radio transmission links can be impaired with high probability owing to environmental effects such as electrical interference, weather, physical obstructions (which may be temporary such as passing vehicles or more permanent such as growing trees or erection of new buildings), etc. It will be appreciated that it can also

be used in wired links, though the cost of providing multiple wired connections to subscribers is likely to be prohibitive in most circumstances.

The following describes a method for implementing the above technique.

Suppose a user at a source node 13 wishes to connect to a user at a destination node 14 with a transmission reliability R. A controller, which may be associated with the source node 13 or which may be an overall system controller for example, computes the number of paths N required to achieve R and the fragmentation factor m given the current bandwidth overhead tolerable and the current worst link reliability R_{link} using the method outlined above.

The system then attempts to set up N independent paths from node 13 to node 14. The result of this is that N' paths can in fact be set up where $N' \leq N$ because of the existing system usage.

If N' is below a threshold, then the system will return a "circuit unavailable" message back to the user.

If N' is satisfactory, then the expected maximum transit time T2 along each of the paths is computed. If this value is incompatible with the traffic type requirements for any of the paths, those paths are rejected. If the remaining number of paths is below the threshold number, a "circuit unavailable" message is returned to the user; if not, then the controller signals to the destination node 14 that N"(that is, the remaining number of paths with satisfactory time delays) transformed data units are to be received on this circuit. The transmission can then proceed.

The user at source node 13 then sends a piece of user data D to the controller in the source node 13. This piece of user data D is fragmented into m discrete units d_i and transformed into N″ new units d^*_i. Each of these transformed data units d^*_i is sent to the destination node 14 each on a different path.

At the destination node 14, the node controller reads received transformed data units d^*_i from the N″ paths and buffers according to the following scheme:

1. At time T1 after receipt of the first transformed data unit, if all N″ transformed data units d^*_i have been received, then the user data D is reconstructed from the input buffer.

2. If at T1, n (< N″) transformed data units d^*_i have been received, and n = N″ - m, then all of the original data units d_i are reconstructed from the n received transformed data units d^*_i and buffered and the user data D is reconstructed from the now complete buffer.

3. If after time T2 after receipt of the first transformed data unit (where T2 > T1), N″-m transformed data units have been received, then the missing data units are reconstructed as in the previous step. If this is not the case, then the missing data units are assumed lost and an errored data packet is reconstructed and sent to the user at the source node 13.

This is repeated for each piece of data D sent from the source node 13 to the destination node 14 (and vice versa) until either party terminates the transmission. Upon transmission termination, when the last data unit has been received, all the paths in the circuit are cleared down by the system.

Normally the parameter T2 must be less than the message reception time-out period of the upper-level protocol (i.e. that being used by nodes 13,14 to communicate). The parameter T1 will be related to the latency of the paths given the current network loading.

An embodiment of the present invention has been described with particular reference to the examples illustrated. However, it will be appreciated that variations and modifications may be made to the examples described within the scope of the present invention.

CLAIMS

1. A method of transferring data between a source and a destination where there are plural communication paths between the source and the destination, the method comprising the steps of:

dividing the data into m discrete units each containing a portion of the data;

transforming said m discrete units into m+n transformed data units where $n \geq 1$;

transmitting each of said m+n transformed data units from said source over the paths such that at least two paths are used for the transmission of the transformed data units from the source;

receiving at least some of the transformed data units at the destination; and,

if at least m transformed data units are received at the destination, reconstructing at the destination the data from at least m transformed data units received at the destination.

2. A method according to claim 1, wherein there are at least m+n transmission paths between the source and the destination, the transmitting step comprising transmitting each of said m+n transformed data units from said source over a different one of the paths.

3. A method according to claim 1 or claim 2, wherein the m discrete data units each contain a different portion of the data.

4. A method according to any of claims 1 to 3, comprising the step of sending an error signal to the source to indicate transmission failure if less than m transformed data units are received at the destination after a predetermined time has elapsed after said transmitting step.

5. A method according to any of claims 1 to 4, wherein the transmission is a wireless transmission.

6. A method according to any of claims 1 to 5, wherein each of the paths is formed from at least one point-to-point wireless transmission link between the source and the destination.

7. Apparatus for transferring data between a source and a destination where there are plural communication paths between the source and the destination, the apparatus comprising:

a divider for dividing the data into m discrete units each containing a portion of the data;

means for transforming said m discrete units into m+n transformed data units where n≥1;

a transmitter for transmitting each of said m+n transformed data units from said source over the paths such that at least two paths are used for the transmission of the transformed data units from the source;

a receiver for receiving at least some of the transformed data units at the destination; and,

means for reconstructing at the destination the data from at least m transformed data units received at the destination if at least m transformed data units are received at the destination.

8. Apparatus according to claim 7, wherein the transmitter is arranged to transmit each of said m+n transformed data units from said source over a different one of the paths.

9. Apparatus according to claim 7 or claim 8, wherein the divider is arranged to divide the data such that each of the m discrete data units contains a different portion of the data.

10. Apparatus according to any of claims 7 to 9, comprising means for sending an error signal to the source to indicate transmission failure if less than m transformed data units are received at the destination after a predetermined time has elapsed after said transmitting step.

11. Apparatus according to any of claims 7 to 10, wherein the transmitter is arranged to transmit wireless transmissions.

12. Apparatus according to any of claims 7 to 11, wherein each of the paths is formed from at least one point-to-point wireless transmission link between the source and the destination.

PRIOR ART

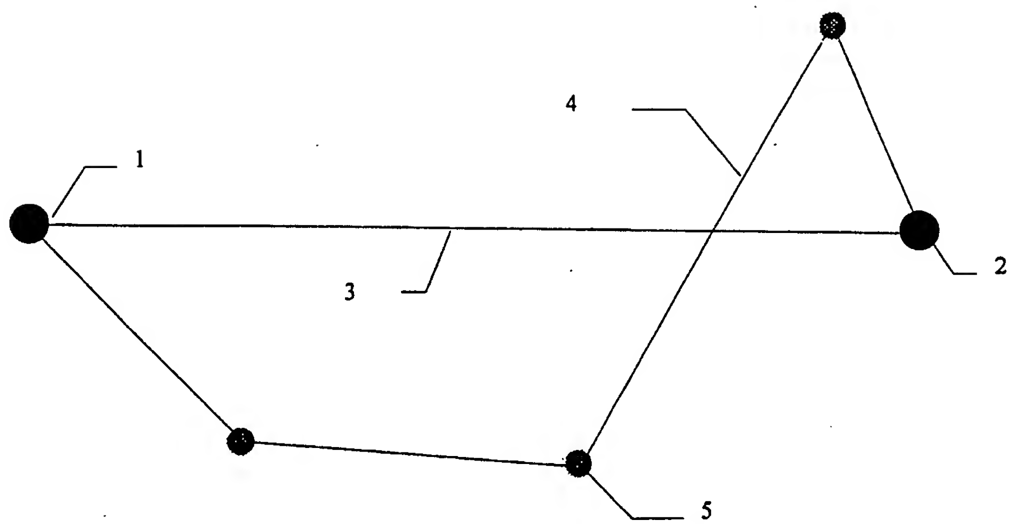

Figure 1

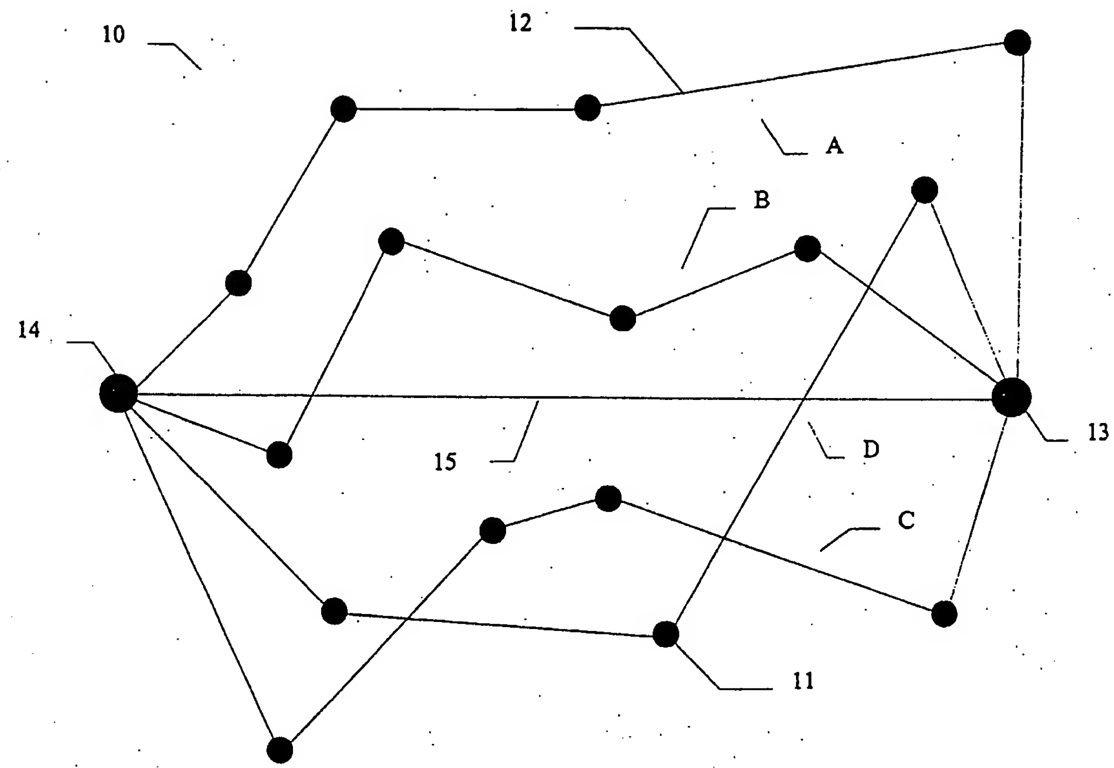

Figure 2

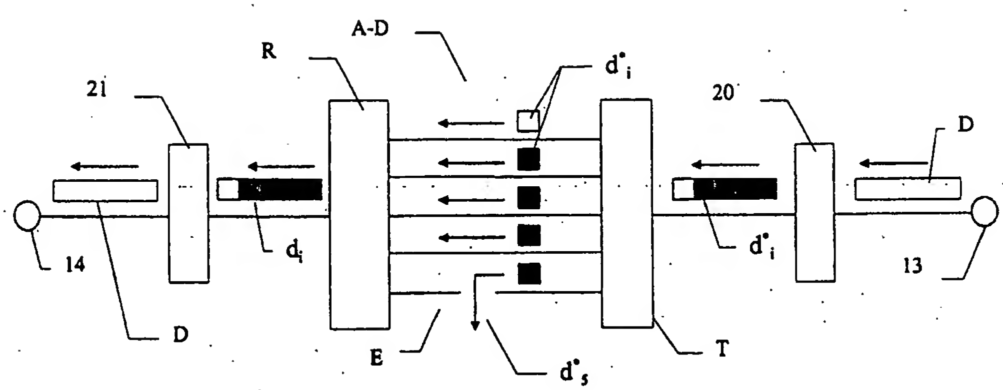

Figure 3

INTERNATIONAL SEARCH REPORT

Inter 'onal Application No
PC1/GB 99/01803

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L29/04 H04L12/56 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MAXEMCHUK N F: "DISPERSITY ROUTING IN HIGH-SPEED NETWORKS" COMPUTER NETWORKS AND ISDN SYSTEMS, vol. 25, 1 January 1993 (1993-01-01), pages 645-661, XP000570119 ISSN: 0169-7552 abstract page 645, left-hand column, paragraphs 1,2 page 646, right-hand column, paragraph 3 -page 648, left-hand column, paragraph 1 page 651, right-hand column, paragraph 4 -page 652, left-hand column, paragraph 4 page 654, left-hand column, paragraph 2 page 659, right-hand column, paragraph 1 --- -/--	1-12

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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25 October 1999	05/11/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blanco Cardona, P

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PCT/GB 99/01803

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 97 32419 A (PHILIPS ELECTRONICS NV ;PHILIPS NORDEN AB (SE)) 4 September 1997 (1997-09-04) abstract page 4, line 31 -page 5, line 22 page 6, line 14 - line 29 ---	5,6,11, 12
A	EP 0 685 952 A (IBM) 6 December 1995 (1995-12-06) column 9, line 32 - line 42 ---	4,10
P,A	WO 98 27694 A (JACKSON TIMOTHY ;NEWMAN JAMES (GB); HUGHES PHILIP THOMAS (GB); RAD) 25 June 1998 (1998-06-25) cited in the application claims 1,40 column 9, line 32 - line 42 -----	1-12

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 99/01803

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9732419 A	04-09-1997	EP 0826278 A	04-03-1998
		JP 11504785 T	27-04-1999
EP 0685952 A	06-12-1995	US 5546549 A	13-08-1996
		JP 7325775 A	12-12-1995
		US 5699532 A	16-12-1997
WO 9827694 A	25-06-1998	AU 5328698 A	15-07-1998
		EP 0947077 A	06-10-1999
		GB 2321368 A,B	22-07-1998
		GB 2330732 A,B	28-04-1999
		GB 2330733 A,B	28-04-1999
		GB 2330734 A,B	28-04-1999